MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, SESSION 2016/2017

EEL4126 – POWER SYSTEM OPERATION AND CONTROL

(LE)

7 OCTOBER 2016
9:00 AM – 11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question Paper consists of FIVE pages including the cover page with FOUR Questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

All the calculation works must be carried out in FOUR decimal points.

Question 1

(a)

(i) What do you understand on the Optimal Power Flow (OPF) problem in an integrated power system? [2 marks]

(ii) Name THREE examples for typical equality and inequality constraints considered in the OPF problem. [6 marks]

(b) A power system is supplied by three plants, all of which are operating on economic dispatch. The incremental cost at the plant of each plant is as following:

Plant	Incremental cost, IC_i ($/MWh)
1	11.00
2	8.00
3	10.00

(i) Based on the given information, briefly explain on the condition that needs to be fulfill in order to have economic dispatch operation amongst the three plants. [2 marks]

(ii) Which plant has the highest penalty factor and which plant has the lowest penalty factor? [2 marks]

(iii) Determine the penalty factor of plant 2, L_2, if the cost per hour to increase the total delivered load by 1 MW is $12.00. [1 marks]

(c) A power plant has three units with the following cost characteristics:

$$C_1 = 0.05\ P_1^2 + 21.5\ P_1 + 500\ R/h$$

$$C_2 = 0.10\ P_2^2 + 27.0\ P_2 + 400\ R/h$$

$$C_3 = 0.07\ P_3^2 + 16.0\ P_3 + 900\ R/h$$

P_1, P_2, and P_3 are the generating power in MW. The maximum and minimum loads allowable on each unit are 140 MW and 42 MW, respectively. Design your system such that all the units are operating under optimal scheduling for a total demand of 300 MW. [12 marks]

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Question 2

(a)

(i) Contingency analysis is abnormal condition in electrical network. Discuss the usefulness of sensitivity factors in contingency analysis of a power system. [5 marks]

(ii) Define generation shift factor in Part (a)(i). [All the variables used in the definition must be defined properly.] [3 marks]

(b) A 3-bus power system is shown in Fig.Q2. The line reactances are: $x_{12} = 0.4$pu, $x_{13} = 0.5$pu, and $x_{23} = 0.2$pu. Bus 3 is the reference bus. The base loads and generations are

Bus	Load (pu)	Gen. (pu)
1	1.0	1.6
2	2.0	1.5
3	1.0	1.8

(i) Find the X-matrix for DC power flow [6 marks]

(ii) Calculate the base power flows on the transmission lines. [6 marks]

(iii) Determine the generation shift factors for line 1-2 for a change in Generation on bus 1. [2 marks]

(iv) Calculate the shift in generation on bus 1 so as to force the flow in line 1–2 to zero. [3 marks]

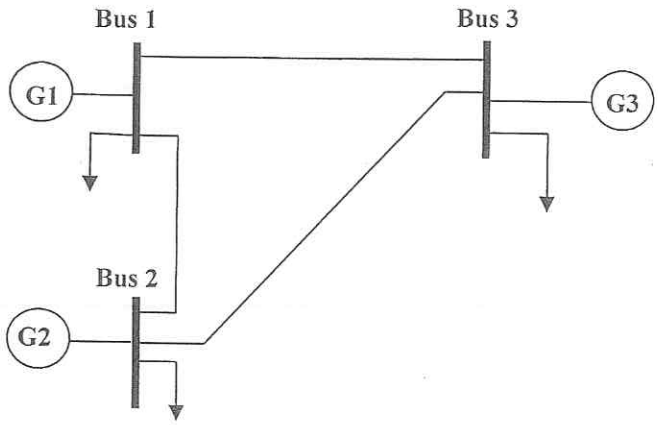

Fig. Q2

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Question 3

(a) Tie-line is the transmission line connecting two areas of the power system. A block diagram representing these interconnected areas, by assuming the tie power flow was defined as going from area 1 to area 2, is as shown in Fig. Q3. Assume there is a sudden load change in area 1, show that the change in tie line power, ΔP_{tie} is given by $\Delta P_{tie} = \Delta\omega(\frac{1}{R_2} + D_2)$. [Note that at steady state the frequency will be constant and equal to the same value on both areas.] [12 marks]

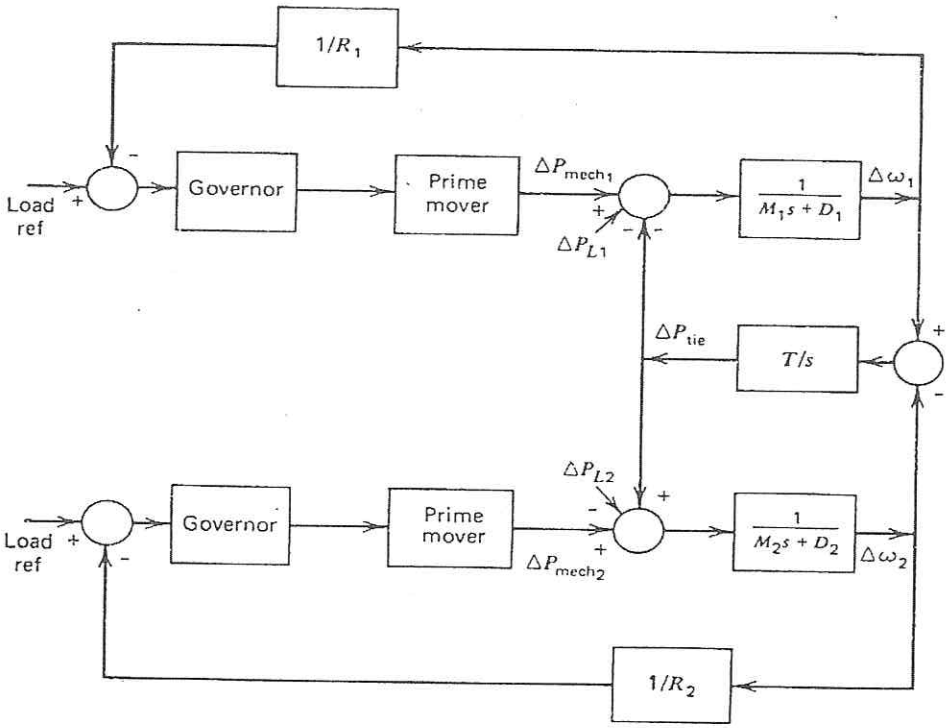

Fig. Q3

(b) Three generators and a load are connected to a bus. The MVA rating and the speed droop, R of each generator are given below:

Generator	Initial load, P_i (MW)	MVA rating	R (p.u. on generator base)
1	80	100	0.01
2	300	500	0.015
3	400	500	0.015

Assume D = 0 and the system frequency is 50 Hz. Determine the new generation in each unit for a 50 MW load increase. [Hints: Use 500 MVA as the system base.] [13 marks]

Continued...

Question 4

(a) A simple model of Automatic Voltage Regulation (AVR) is as shown in Fig. Q4. This system might become unstable when there is a change on the amplifier gain. In order to increase the relative stability of the system, an excitation system stabilizer can be added to the system.

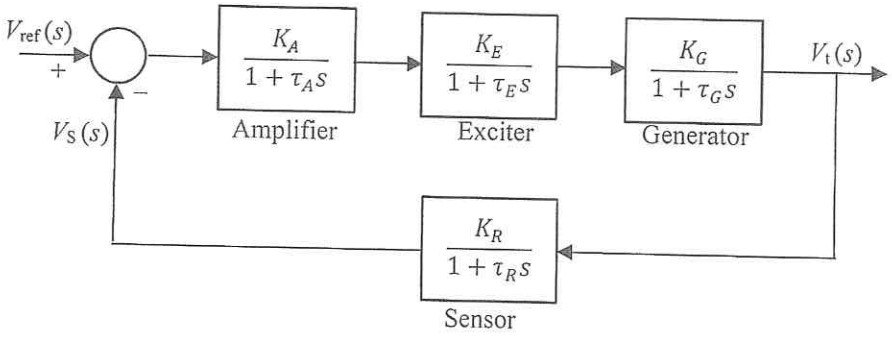

Fig. Q4

(i) Draw the block diagram of the AVR system compensated with the rate feedback stabilizer. What is the purpose to have this stabilizer added to the AVR? [3+2 marks]

(ii) Draw the block diagram of the AVR system compensated with the proportional integral derivative (PID) controller. What is the function of the PID controller in the AVR system? [3+2 marks]

(b) Based on the excitation power source used, state the various types of excitation systems used for synchronous machine. [3 marks]

(c) In a large interconnected power system where the power is transmitted over long transmission lines, the losses are a major factor affecting the optimum dispatch of generation. The total transmission line loss (P_l) is given as

$$P_L = \sum_{i=1}^{n_g}\sum_{j=1}^{n_g} P_i B_{ij} P_j, \quad i = 1,2,\ldots..,n_g$$

where B_{ij} is the loss coefficient; P_i & P_j = generator power output for unit-i and unit-j, respectively. Briefly explain the procedure of lambda (λ) iteration method for optimal dispatch generation. [12 marks]

End of Paper.